



CHANGES IN ARTERIAL HEMOGLOBIN OXYGEN SATURATION DURING  
TRANSPORT FROM THE OPERATING ROOM TO THE POSANESTHESIA CARE  
UNIT IN HEALTHY PATIENTS BREATHING ROOM AIR

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## ABSTRACT

Hypoxemia is a complication that appears postoperatively and may linger for several days. This hypoxemia can be due to either reduced Functional Residual Capacity (FRC), hypoventilation, or ventilation-perfusion mismatch. The persistence of ventilatory depression induced by anesthetics and neuromuscular blocking drugs can magnify the hypoxemia. Pulse oximetry allows for continuous indirect measurement of the oxygen saturation of arterial hemoglobin ( $\text{SaO}_2$ ). The purpose of this study is to determine the  $\text{SpO}_2$  during transport in patients who receive room air, and to determine if there is a difference in  $\text{SpO}_2$  in the operating room (OR) compared to  $\text{SpO}_2$  on arrival to the Postanesthesia Care Unit (PACU). The sample consisted of 14 ASA I and II healthy adults, age 18 to 60 years, undergoing general anesthesia with endotracheal intubation. All the subjects breathed room air during an average transport time of 45 seconds.  $\text{SpO}_2$  was recorded just prior to transport from the OR and on arrival to the PACU prior to institution of supplemental oxygen. Data analysis showed a statistically significant decrease in  $\text{SpO}_2$  in the PACU ( $96.1 \pm 2.2$ ) compared to the OR ( $99.4 \pm 0.63$ ). These data imply that hemoglobin oxygen desaturation may occur during a 45 second transport to the PACU in healthy patients breathing room air.

KEY WORDS: Oxygen, Hypoxemia, Pulse Oximetry, Oxygen Saturation, Hemoglobin

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by

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## **PREFACE**

This research was conducted to identify if ASA I and II patients who do not receive enhanced  $\text{FiO}_2$  are adequately oxygenated with  $\text{SpO}_2$  greater than 94% during transport to the PACU. It was designed to provide information to Army anesthesia providers in future patient care.

## **DEDICATION**

To my mother and father, I dedicate the creation of this thesis. Without their love, encouragement, and support the attainment of a dream and the creation of this thesis would not have been possible.

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## CHAPTER I - INTRODUCTION &amp; FRAMEWORK

## Background

It is well documented that arterial oxygen desaturation can develop in the early postoperative period and can last for several hours if not days (Graham, Chang, & Steven, 1986). If patients receive room air or low inspired oxygen fraction ( $FiO_2$ ) during the first 10 minutes after anesthesia with nitrous oxide, diffusion hypoxia leading to hemoglobin oxygen desaturation can occur. This phenomenon is due to reequilibration of nitrous oxide from the bloodstream into the alveolus after the nitrous oxide is discontinued. This effectively dilutes the inspired oxygen and nitrogen, producing a lower concentration of both gases, which may lead to a transient hypoxemia. This occurs because nitrous oxide is 31 times more soluble in blood than nitrogen. If nitrogen was more soluble in blood than nitrous oxide this would not occur due to rapid equilibration of nitrogen in the bloodstream and maintenance of a reasonable inspired oxygen fraction in the immediate postoperative period.

Most postanesthesia care units (PACUs) administer supplemental oxygen in the immediate postoperative period to minimize the incidence of hypoxemia experienced by patients in this setting (Graham, et al., 1986). However, there are insufficient data available substantiating the use of supplemental oxygen when transporting patients to the PACU from the operating room (OR). In fact, Biddle and Holland (1987) found that adequate oxygenation could be maintained in physically fit patients by positioning and deep breathing

alone. The need for postoperative oxygen therapy after surgery involving an incision to the thorax or upper abdomen has been well documented (Gift, Stanik, Karpenick, Whitmore, & Bolgiano, 1995). Further data suggest a correlation between age and postoperative arterial oxygen desaturation (Nunn, 1965). This correlation seems to be due to the relationship between age and the mismatch of ventilation to perfusion as well as age related increases in the volume of the lungs at which small airways close (Kitamura, Sawa, & Ikezono, 1972).

Chripko, Bevan, Archer, and Bherer (1989) found a high incidence of desaturation (27%) in pediatric patients breathing room air during transport from the OR to the PACU. Canet, Ricos, and Vidal (1989) found that oxygen hemoglobin saturation increased in patients who had a "peripheral" site for surgery while they breathed room air during their first 10 minutes in the PACU. This questions the need for oxygen therapy in those having surgery to the face, neck, lower abdomen, or extremities. (Gift, et al., 1995). In addition, American Society of Anesthesiologist (ASA) physical status scores have been found to be predictive of surgical patients who will have an hypoxic episode (Cullen, Nemeskel, & Cooper, 1992).

In the absence of an adequate noninvasive monitoring device, it has been considered wise practice to administer oxygen therapy to all postoperative patients. Monitoring oxygenation with pulse oximetry is now a standard of care in surgery and the immediate postoperative period. This device allows the noninvasive monitoring of oxygen saturation to indicate the need for oxygen therapy (Gift, et al., 1995).

According to Gift et al.:

the routine use of oxygen therapy in patients at low risk for hypoxemia who have adequate oxygen saturation may be an unwarranted expense. Clinical practice for use of oxygen varies among institutions; some require oxygen therapy for this group of patients and others do not (p. 368).

Hypoxemia and the need for supplemental oxygen often persist in patients for a period of minutes to hours following surgery (Marshall, & Wyche, 1972). Jacobsen, Nielsen, Brinklov, Stokke, and Hartmann-Anderson (1980) suggest impairment of arterial oxygenation in the postoperative period is a common occurrence even in pediatric patients without evidence of preexisting respiratory or cardiovascular disease. In this study of 13 patients with normal arterial carbon dioxide ( $\text{PaCO}_2$ ), cardiac output and pulmonary function, Jacobsen et al. found a mean  $\text{PaO}_2$  of 66.75 mm Hg after administration of general anesthetics.

Oxygen therapy to increase the oxygen saturation from one normal level to another has a cost and may have very little benefit. There is a ceiling effect for oxygen therapy when  $\text{SpO}_2$  achieves 100% (Gift, et al., 1995). Increasing the  $\text{SpO}_2$  from 95% to 100% by providing supplemental  $\text{O}_2$  may not have any physiological benefit (Katsuya, & Sakanashi, 1989). The advent of pulse oximetry allows accurate determination of those at most risk for hypoxemia, and oxygen may selectively be administered to those who need it. DiBenedetto, Graves, Gravenstein, and Konicek (1994) questioned the routine use of

supplemental oxygen for all patients during the time of transport from the OR and in the PACU. In their study of 500 postoperative adult patients breathing room air, 307 maintained O<sub>2</sub> saturations above 94% and did not require O<sub>2</sub> supplementation. This represented a savings to those patients of \$31,928, and a potential annual savings of \$623,272. They suggested that supplemental oxygen only be used when a need is demonstrated. Conversely, Graham et al. (1986) believed that "consideration should be given to routine oxygen administration during transit from the OR to the PACU, especially in the elderly patient and if the transport time is not brief. However, the Graham et al. study was conducted prior to the routine availability and use of pulse oximetry as is mandated today.

In addition to considering the use of supplemental oxygen during the transport period to the PACU, some attention must also be given to the transport time itself. Canet, et al. (1989) found significant differences in oxygen saturation when administering 35% oxygen to adults in the PACU after a 30-second transport while breathing room air. Hoffman, Nakamoto, Okal, and Clochesy (1991) indicated patients may experience transport times longer than 240 seconds depending on the distance between individual operating rooms and the PACU. In addition, transport frequently occurs in an uncontrolled environment without oxygen and resuscitation equipment immediately available. Although it has been postulated that early hypoxemia lasts approximately two hours after a surgical procedure, the first 20 minutes of the postoperative period seem to be most

critical (Canet et al., 1989). It is evident that the majority of transport times would fall well within this 20 minute window, thus the potential for postoperative hypoxemia during the transport period does exist.

Operative site and method of O<sub>2</sub> delivery may play a role in postoperative oxygen saturation. Hudes, Marans, and Hirano (1989) studied 101 elective surgical patients and found no difference in oxygen saturations between patients given oxygen by nasal cannula (mean SpO<sub>2</sub> 96.6%) compared to those given 40% oxygen by face mask (mean SpO<sub>2</sub> 96.7%). Korey, Burgman, Sweet, and Smith (1962) also found oxygen saturations to be only slightly lower with the nasal cannula. This led them to recommend the nasal cannula for oxygen therapy because of the decreased cost, greater ease of administration, and increased patient comfort. Gift, et al. (1995) suggest oxygen at 4 liters per minute via nasal cannula maintains adequate oxygen saturation levels.

The site of operation has also been associated with postoperative hypoxia. It has been demonstrated that in the immediate postoperative period patients who had thoracic or abdominal surgery had significantly lower SpO<sub>2</sub> levels. Ambulatory patients are less likely to have associated risk factors such as abdominal or thoracic incisions, obesity, respiratory disease, or increased age that predispose surgical inpatients breathing room air to hypoxemia (Diament & Palmer, 1966; Drummond & Milne, 1977; Kitamura et al., 1972; Marshall & Millar, 1965;). Thus, routine supplemental oxygen may not be necessary after ambulatory surgery (Murray,

Raemer, & Morris, 1988).

Two studies have involved ASA Class I and II patients. The first study involved 164 healthy adult women who had primarily gynecological surgical procedures under general anesthesia. Postoperatively 7% of the patients had  $\text{SpO}_2 \leq 92\%$ , 4% had readings  $\leq 90\%$ , and the lowest  $\text{SpO}_2$  was 80% after transport to the PACU breathing room air. In no case was there clinically evident respiratory depression or obstruction, or signs of hypoxemia (e.g., cyanosis or tachypnea). Providing supplemental oxygen increased  $\text{SpO}_2$  to  $\geq 95\%$  within 2 minutes and maintained these levels in all cases (Murray, et al., 1988). The authors recommended supplemental oxygen to all ambulatory patients recovering from general anesthesia. Another study involved 71 healthy pediatric patients undergoing general anesthesia. Significant arterial desaturation of  $\text{SpO}_2$  less than 90% occurred in 28.1% of the group who were breathing room air during the transfer from the operating room to the postanesthesia care unit (Pullerits, Burrows, & Roy, 1987). Both of these studies used ASA Class I and II patients who received general anesthesia

#### Problem

Patient safety is the goal of anesthesia providers. Early postoperative hypoxemia can occur (Hoffman, et al., 1991). Patients who are at risk for developing postoperative hypoxemia as well as those patients who are not at risk have not been clearly identified. Presently, it is unknown whether there is a physiologic need for enhanced inspired oxygen

therapy during transport from the OR to the PACU for healthy postoperative patients.

#### Purpose of the Study

The purpose of this study is to determine if there is a decrease in SpO<sub>2</sub> in the OR compared to SpO<sub>2</sub> on arrival to the PACU in patients who breathe room air during transport. The specific aim of this study is to identify if ASA I and II patients who breathe room air are adequately oxygenated as measured by SpO<sub>2</sub> greater than 94% during transport to the PACU.

#### Research Question

The research question of this study is:

In the healthy ASA I and II patient having non-thoracic and non-abdominal surgery does transport from the OR to the PACU breathing room air have a negative impact on arterial SpO<sub>2</sub> resulting in hypoxemia?

#### Conceptual Model

The conceptual framework for this research is the Roy adaptation model (Galbreath, 1985). Roy's model focuses on the concept of adaption of man. The basic premise of the Roy model is that the patient or individual is considered an adaptive system. According to Roy (1976) a person is a biopsychosocial being in constant interaction with a changing environment. In the Roy model the individual functions as a system because individuals are in constant interaction with

their environments exchanging information, matter, and energy. Roy (1984) defines environment as all the conditions, circumstances, and influences surrounding and affecting the development and behavior of the person. As an open, living, system, the person receives inputs or stimuli from both the environment and the self (Blue et al., 1994). Adaptation occurs as a result of the interaction as well as the individual's efforts to maintain integrity.

Patients during transport from the OR to the PACU represent an adaptive system exposed to the stress of surgery and effects of anesthetic agents. These interactions with the environment by the postoperative patient are characterized by internal and external change (Galbreath, 1985). The postoperative patient has a decreased ability to respond to inputs or stimuli and maintain integrity of the system. Anesthesia providers function to interpret data and provide intervention to maintain the system on behalf of the patient. Monitoring SpO<sub>2</sub> and providing supplemental oxygen help to maintain integrity of the system. An individual who is anticipating or has undergone any type of surgery under general anesthesia has certainly experienced some degree of challenge to his or her adaptive system.

#### Definitions

Pre-transport SpO<sub>2</sub>: The arterial hemoglobin oxygen saturation as measured immediately prior to transport from the OR to the PACU.

Post-transport SpO<sub>2</sub>: The arterial hemoglobin oxygen saturation as measured immediately upon arrival in the PACU from the OR.

### Limitations

The limitations of the study are:

1. The patient response level leaving the OR varied from patient to patient.
2. The time and dose of the last narcotic was not controlled.
3. The study was not controlled for the type of general anesthesia.
4. The size of the sample was small.
5. The same pulse oximeter was not used to measure SpO<sub>2</sub> in the OR and in the PACU.
6. Time of transport was not measured for each patient

### Summary

Existing studies are unclear regarding the use of supplemental oxygen when transporting patients from the OR to the PACU. Healthy patients may breathe room air oxygen during transport when ventilation is likely to be depressed from residual inhalational anesthetic agents, narcotics and muscle relaxants. It is unclear whether it is safe or unsafe to transport ASA I and II patients from the OR to the PACU breathing room air. This study will help to determine if enhanced inspired O<sub>2</sub> is necessary during transport from the OR to the PACU for ASA I and II patients who have had non-abdominal and non-thoracic surgery.

## CHAPTER II - REVIEW OF RELEVANT LITERATURE

Nearly 50 years ago McClure, Behrmann, and Hartman (1948) identified hemoglobin-oxygen desaturation as a complication of general anesthesia. The current health care environment driven by economic constraints has motivated research in the area of postoperative oxygen therapy and patient safety. Research regarding the pathogenesis of perioperative desaturation and technologic advances in the detection of arterial desaturation have played a role in improving anesthesia patient safety. Oxygen therapy postoperatively entails increased cost as a result of either the need for additional therapy because of higher acuity of care or longer hospitalization.

Breathing room air postoperatively has been identified by some as inappropriate for anesthetized patients (Marshall & Wyche, 1972; Nunn, 1964). Tyler, Tantisira, Winter, and Motoyama (1985) stated "there is a surprising lack of data on patient oxygenation during postoperative transfer, explainable in part by the difficulty of measuring blood gases under such conditions (p.1108)." Yelderman and New (1983) found that the measurement of SpO<sub>2</sub> by pulse oximetry linearly accurate and precise in the range of 70 - 100%. The advent of pulse oximetry heralded the inception of a new era for monitoring oxygen saturation during and after surgery.

Pulse oximeters noninvasively measure the oxygen saturation of hemoglobin in arterial blood. The two types of oximeters are transmissive pulse oximeters and reflectant pulse oximeters. Transmissive oximeters measure the

absorption of light passed through an arterial bed and reflectant oximeters measure reflected light. In the more commonly used transmissive oximeter, light passes through a tissue bed such as a finger or an earlobe to the photodetector opposite the light source (Barash, Cullen, & Stoelting, 1996). The oximeter transmits red (660nm) and infrared (940nm) wavelengths of light through tissue. After the light passes through the tissue, the photodetector in the probe converts the transmitted light energy into an electronic signal proportional to the absorbency. Because blood changes color in accordance with its degree of oxygenation, the proportion of transmission of red and infrared light is analyzed to calculate the color of the intervening as percent oxygen hemoglobin saturation. The measured ratio of the red to the infrared absorbency during pulsatile and nonpulsatile flow is then related to the ratio of the red to the infrared "pulse added" (AC/DC) absorbency to a nonlinear function of arterial oxygen saturation. The "pulse added" absorbency is the ratio of the pulsatile (AC) component to the nonpulsatile (DC) component of absorption at each wave length (Tremper, & Barker, 1989).

Improper functioning of the pulse oximeter can occur with motion artifact, electrical noise from the electrocautery, intravenous dyes such as methylene blue and indocyanine green, carboxyhemoglobin and methemoglobin, ambient light, nail polish, and poor extremity blood flow from hypotension and vasoconstriction (Barash et al. 1996). Pulse oximetry accurately measures  $SpO_2$  in the range of 65% to 100% (Mihm & Halperin, 1985). The  $SpO_2$  may be falsely elevated

in smokers who have elevated arterial carboxyhemoglobin because the oximeter fails to distinguish between oxyhemoglobin and carboxyhemoglobin (Patel, Norden, & Hannallah, 1988). Thus, smokers have not been included in this study.

Pulse oximetry has made the continuous measurement of SpO<sub>2</sub> in the OR and the PACU routine (Craig, 1981). Oxygen hemoglobin saturation during the early period of anesthetic recovery, however, has not been extensively and continuously measured using pulse oximetry (Canet et al., 1989). In the last few years several studies have analyzed oxygen desaturation during transfer to the PACU (Chripko et al., 1989; Hoffman et al., 1991; Pullerits et al., 1987; Scuderi et al., 1996; Tyler et al., 1985). These studies examined the pediatric population and reported conflicting results. Although routine administration of oxygen during the postoperative period is accepted, the benefit of this therapy as measured by changes in SpO<sub>2</sub> has not been extensively reported (Canet et al., 1989). Several studies (Graham et al., 1986; Tyler et al., 1985) recommend supplemental oxygen for all patients during transport between the operating room and the PACU to prevent hypoxemia. "While the nasal cannula and simple face mask are the devices most often used in providing supplemental oxygen, research has neither demonstrated nor compared their effectiveness in preventing hypoxemia during the transport period" (Adamson & Janken, 1992, p.356). Studies done in the PACU have demonstrated the efficacy of these devices in the prevention of hypoxemia (Williams, Jones, & Mapleson, 1988; Murray et al., 1988).

Adamson and Janken (1992) compared the effectiveness of nasal cannula and face masks in maintaining  $\text{SpO}_2$  during transport to the PACU. Their study showed that both devices maintained the  $\text{SpO}_2$  above hypoxic levels ( $\text{SpO}_2 > 90\%$ ). However, the mean  $\text{SpO}_2$  at the end of the transport period for the face mask group was higher than the mean for the nasal cannula group. Scuderi et al. (1996) concluded that  $\text{O}_2$  administration by nasal cannula is a more cost-effective alternative for routine postoperative  $\text{O}_2$  administration.

## CHAPTER III - METHODOLOGY

### Introduction

This study was conducted in the anesthesia department of a large Navel Medical Center. A sample of 14 adults aged 18 to 60 having non-thoracic and non-abdominal ambulatory or inpatient surgical procedures under general anesthesia was used. Subjects were randomly selected, and the SpO<sub>2</sub> was measured on patients by using a pulse oximeter in the OR prior to transport and then again using the same pulse oximeter upon arrival to the PACU prior to placement of supplemental oxygen.

### Research Design and Procedure

Approval by the Institutional Review Board (IRB) was obtained. The investigator discussed the proposed study with potential subjects during the preanesthesia interview or in the preoperative holding area. Patient's questions were answered. Confirmation of the patient's ability to participate in the study based on the inclusion and exclusion criteria was made. Patients who were willing to participate in the study who met the inclusion/exclusion criterion signed the consent. (Appendix A)

Demographic information was collected for all subjects. The general anesthetic management was left to the discretion of the anesthesia provider. Each patient was moved to a stretcher from the operating room bed after extubation in preparation for transport to the PACU. The head of the stretcher was elevated to 30 degrees after the patient was

moved. All patients breathed room air during transport and SpO<sub>2</sub>'s were measured in the OR before transport to the PACU and again upon arrival in the PACU prior to administering supplemental O<sub>2</sub>. The average transport time from the OR to the PACU was measured by averaging the time of transport for six patients of the study and calculating the mean.

#### Sample

A sample of 14 adults aged 18 to 60 years having non-thoracic and non-abdominal surgery was used. The patients met the following inclusion criteria:

1. not involved in another research project
2. did not require preoperative supplemental oxygen
3. ASA classification I and II
4. 18 to 60 years of age
5. nonsmoker
6. undergoing surgical procedure with general anesthesia with endotracheal intubation
7. non-thoracic and non-abdominal surgery
8. free from complications during anesthesia
9. successfully extubated in the operating room.

Patients were not included in this study because of the following exclusion criteria:

1. smokers
2. abdominal or thoracic surgery
3. ASA III/IV and emergency surgeries.
4. age less than 18 years of age or greater than 60 years.

### Measurement

Different pulse oximeters in the OR and the PACU were used to assess arterial hemoglobin oxygen saturation. This measurement was made just prior to leaving the OR with the oximeter in the OR and upon arrival in the PACU with the PACU oximeter.

### Data Collection

The following information was recorded for each patient on the data collection form (Appendix B):

1. Age (years)
2. ASA status
3. Preoperative SpO<sub>2</sub> (%)
5. Pre-transport SpO<sub>2</sub> (OR)
6. Muscle contraction tetany 100Hz (yes, no)
7. Post-transport SpO<sub>2</sub> (PACU)
8. Anesthetic agent
9. Anesthesia time (minutes)
10. Weight

### Data Analysis

Descriptive statistics were used to summarize the patient demographics. A one-tailed, paired t-test was employed to compare pre-transport SpO<sub>2</sub> and posttransport SpO<sub>2</sub> upon arrival to the PACU. The t-test provides a reduction of Type I errors that may occur if normal curve values are applied to small sample sizes. Data analysis was performed using the Statistical Package Social Sciences (SPSS). To

determine statistical significance the alpha was set at  $P \leq 0.05$  (Scheffler, 1984). The sample size of 14 provided a power of .80 with an alpha of  $P \leq 0.05$  in a two tailed test with a critical effect size of .60. Subject characteristics of age, baseline  $SpO_2$ , surgery time, pre-transport  $SpO_2$  and post-transport  $SpO_2$  were determined. Frequency distributions for the variables, gender, ASA status, and surgical procedure were determined.

## CHAPTER IV - ANALYSIS OF DATA

## Presentation, Analysis &amp; Interpretation of Data

It was hypothesized that transport from the OR to the PACU breathing room air has no impact on SpO<sub>2</sub>. All subjects were were ASA I or II between the age of 22 to 57 years old (Table 1). Nine male and five female patients were included in the study. Nine patients were classified as ASA I, with the remainder classified as ASA II. Mean age was 32.9 years, with a range of 22 - 57 years (Table 2). Mean weight was 80.5 kg, with a range of 60 - 130 kg. General anesthesia with desflurane, isoflurane or fentanyl with endotracheal intubation was used. Adequate reversal was obtained on patients who were given muscle relaxants. Preoperative SpO<sub>2</sub> ranged from 97-99%. Surgical time ranged from 42-560 minutes.

All patients were premedicated with Midazolam. Seven patients were induced with Propofol, six with Thiopental, while one patient received both induction agents medications during the procedure. Ten patients were given Isoflurane, three Desflurane, and one patient received both anesthetic agents. Thirteen patients received intraoperative fentanyl and one patient received both fentanyl and morphine.

The average surgical time was 166.6 minutes with range of 42 to 560 minutes. Eleven of the 14 patient received neuromuscular blocking agents with all patients exhibiting sustained tetany at the end of the procedure.

The pre-transport SpO<sub>2</sub> was statistically significantly greater ( $p < 0.05$ ) than the post-transport SpO<sub>2</sub> as (Table 3).

The average pre-transport SpO<sub>2</sub> was 99.37% with a range of 98-100%. The average post-transport SpO<sub>2</sub> was 96.07% with a range of 92-99%. The probability level for the difference between the pre and post-transport SpO<sub>2</sub> was less than 0.0005. The mean transport time for six patients was 43.33 seconds with a range of 28-55 seconds.

A correlation analysis of the variables, preoperative SpO<sub>2</sub> and the postoperative SpO<sub>2</sub> found a positive correlation between the two measurements ( $r = .41$ ). A correlation analysis of the variables patient weight, and postoperative SpO<sub>2</sub> found a weak, negative correlation between the measurements ( $r = -.21$ ).

Table 1

Frequency Distribution for Subject Characteristics


---

Sex	
Male	9
Female	5
ASA Status	
I	9
II	5
Preoperative Sedation	
Midazolam	14
IV Agents	
Thiopental	6
Propofol	7
Thiopental + Propofol	1
Inhalation Agents	
Isoflurane	10
Desflurane	3
Isoflurane and Desflurane	1
Narcotics	
Fentanyl	13
Fentanyl + Morphine	1
Neuromuscular Blockade	
Received	11
Not Received	3
Postreversal Tetany	
Yes	14
No	0

---

Table 2

Means and Statistical Deviations for Subject Characteristics

Stats	Age (years)	Weight (Kg)	Preop SpO <sub>2</sub> (%)	Surgical Time (minutes)
Mean	32.9	80.5	97.9	166.6
Standard Deviation	9.3	18.9	.77	154.9
Range	22 - 57	60 - 130	97 - 99	42 - 560

Table 3

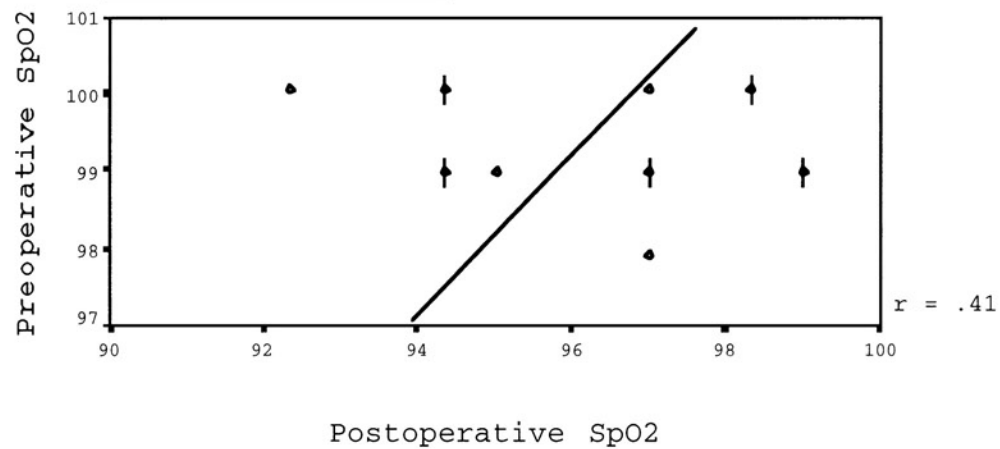
Subject Oxygen Saturation Data

Patient	Preop	OR	PACU	(Preop - PACU)	(OR - PACU)
1	98	99	95	3	4
2	98	100	92	6	8
3	97	100	98	-1	2
4	98	99	99	-1	0
5	98	99	97	1	3
6	97	98	97	0	1
7	99	100	97	2	3
8	97	100	94	3	6
9	98	99	97	1	2
10	97	99	94	3	5
11	98	100	94	4	6
12	97	99	94	3	5
13	99	99	99	0	0
14	99	100	98	1	2
Mean	32.8	99.4	96.1	1.79	3.36
SD	.77	.63	2.2	2.01	2.41
Range	97-99	98-100	92-99	-1 to 6	0-8

A Pearson correlation coefficient ( $r$ ) was used to measure the association between the preoperative  $\text{SpO}_2$  and the postoperative  $\text{SpO}_2$  recorded in the PACU as seen in Figure 1. A positive correlation between the two measurements was found ( $r = .41$ ).

Figure 1

Correlation Between Preoperative  
 $\text{SpO}_2$  and PACU  $\text{SpO}_2$

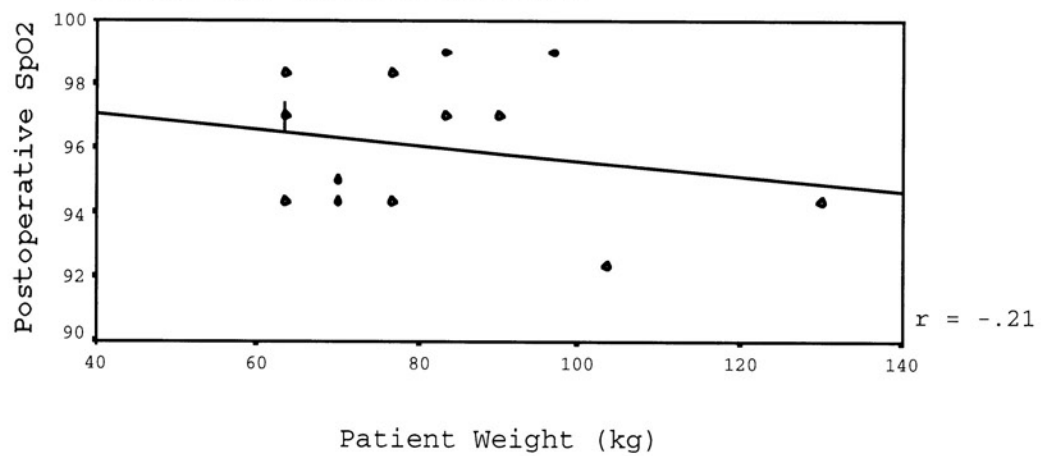


A Pearson correlation coefficient ( $r$ ) was used to measure the association between the patient weight and postoperative  $\text{SpO}_2$ . A weak negative correlation between the two sets of measurements ( $r = -.21$ ) was found (Figure 2).

Figure 2

Correlation Between Patient

Weight and Postoperative  $\text{SpO}_2$



## CHAPTER V - CONCLUSIONS

## Conclusion &amp; Recommendations

Low risk ambulatory surgery and inpatients participated in this study. Ambulatory surgery is becoming an integral part of our health care system, along with the increasing trend towards hospital downsizing. Patients are being operated on sooner and being discharged earlier as a result of cost containment efforts. These trends require anesthesia providers to increase vigilance during transport from the OR to the PACU a period when the patient is most vulnerable to complications.

Existing studies are unclear regarding the use of supplemental oxygen when transporting patients from the OR to the PACU. During transport following surgery ventilation is likely to be depressed from residual inhalational anesthetic agents, narcotics and muscle relaxants (Tyler et al., 1985). It is common practice for patients to receive supplemental O<sub>2</sub> therapy upon arrival to the PACU because of the well documented, incidence of hypoxemia that occurs following anesthesia and surgery.

It is well documented that arterial oxygen desaturation can develop in the early postoperative period and can last for several hours if not days (Graham et al., 1986). Tyler et al. (1985) found that administration of 100% O<sub>2</sub>, even to patients with normal minute ventilation, does not guarantee normal SpO<sub>2</sub> during transport if there is an excessive alveolar-arterial oxygen gradient (A-aDO<sub>2</sub>). This phenomenon

occurs because equilibration of  $\text{SaO}_2$  with inspired gas mixtures may take up to several minutes in the postoperative patient. Tyler et al. demonstrated that hypoxemia occurred in a significant percentage of patients having surgery involving incisions to the thorax or upper abdomen. Canet et al. (1989) found a mean  $\text{SpO}_2$  of 90.7% with a sample of 209 nonhomogeneous patients scheduled for elective surgery were breathing room air during the first 10 minutes after arrival in the PACU. The need for oxygen therapy in those patients having surgery to the face, neck, or extremities has not been definitely established.

This study excluded patients with any significant preoperative disease and patients with abdominal or thoracic incisions. American Society of Anesthesiologist (ASA) physical status score have been found to be predictive of surgical patients who have hypoxic episodes (Cullen et al., 1992). Selection was limited to subjects having an ASA physical status classification of either I or II. These patients are less likely to have risk factors for postoperative hypoxemia.

The ages of patients in this study ranged from 22 to 57 years. Murray et al. (1988) found that general anesthesia produced a greater reduction of functional residual capacity (FRC) and increased ventilation perfusion mismatches with advancing age. In addition, it was found that postoperative  $\text{SpO}_2$  decreases with age. Kitamura et al. (1972) found that true pulmonary shunt increases in patients postoperatively and is increasingly evident with age.

The patients in this study were required to have general

endotracheal anesthesia. Patients requiring endotracheal anesthesia have respiratory and physiologic changes which may lead to a postoperative decrease in  $SpO_2$ . These changes occur because of abnormal pulmonary gas exchange due to atelectasis, respiratory depression, or upper airway obstruction. McCarthy (1987) states that general anesthesia causes increased ventilation-perfusion mismatch by decreasing FRC, increasing airway closure, decreasing pulmonary artery pressure, increasing alveolar pressure and inhibition of the hypoxic pulmonary vasoconstrictive reflex.

The small number of subjects employed in this study imparts a need to replicate this study using a larger sample size. Caution must be taken in interpreting the results of this study because of the small  $n$  (sample size=14), which lowers its statistical power.

#### Overview of Results

This study demonstrated that in the healthy patient breathing room air for transport following non-thoracic, non-abdominal surgery there was a decrease in the PACU  $SpO_2$  compared to the  $SpO_2$  in the OR. Chripko et al. (1989) also found a high incidence of desaturation (27%) in pediatric patients breathing room air during transport from the OR to the PACU. This study also found that there was a weak negative correlation between the preoperative patient weight and postoperative  $SpO_2$ .

It is accepted policy and practice to administer supplemental oxygen therapy to postoperative patients. Pulse

oximetry is now considered a standard of care in the OR and the PACU. Gift et al.(1995) suggests that monitoring of the SpO<sub>2</sub> via pulse oximetry informs providers of the need for supplemental oxygen therapy. Anesthesia providers have responsibility for patient safety and wellbeing both intraoperatively and in the immediate postoperative period.

Researchers and physiologist have failed to agree on the SpO<sub>2</sub> that indicates a clinically significant hypoxemia. The literature suggests that many clinicians accept a SpO<sub>2</sub> of 90%, or even less, as a clinically significant indicator of hypoxemia. This SpO<sub>2</sub> is not an acceptable level intraoperatively or postoperatively. Because of the close proximity of the operating rooms to the PACU at the Navel Medical Center perhaps research done in situations where transport time may be lengthy would provide different results.

### Summary

Information exists surrounding oxygen delivery systems, pulmonary complications and patient conditions that are conducive to postoperative pulmonary complications. This study evaluated whether breathing room air oxygen had significant impact on the immediate postoperative SpO<sub>2</sub>. Results demonstrated that there was a reduction in SpO<sub>2</sub> between the OR and the PACU. No predictive correlation was found between preoperative SpO<sub>2</sub> or patient weight and postoperative SpO<sub>2</sub>. These data indicate that SpO<sub>2</sub> may decrease during transport to the PACU implying that the safest way to

transport patients is with supplemental oxygen to prevent hypoxemia. Further research is warranted.

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## APPENDICES

## Appendix A

(Rev 1/98)  
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Date:

NATIONAL NAVAL MEDICAL CENTER  
BETHESDA, MARYLAND

Consent for Voluntary Participation in a Clinical  
Investigation Study

1. I, \_\_\_\_\_, have been asked to voluntarily participate in a research project entitled, "Changes in Arterial Hemoglobin Oxygen Saturation During Transport From The Operating Room To The Postanesthesia Care Unit In Healthy Patients" being conducted at the National Naval Medical Center, Bethesda, Maryland.
2. This study will evaluate whether there is a difference in the oxygen saturation (amount of oxygen in the blood) of arterial hemoglobin (oxygen carrying part of the blood) during transport in patients who breath room air.
3. I understand my participation in this research project will be for a period of time that I am being transported from the operating room to the recovery room
4. The procedure for this project involves the following: You must meet all of the required criteria and permit the use of a device that clips on your finger that measures the amount of oxygen in your blood. Subjects will have their blood oxygen levels measured immediately after surgery and upon arrival to the recovery room.
5. Specifically, I am aware that the experimental part of this research is the use of a pulse oximeter (device that measures the amount of oxygen in your blood).
6. A total of 30 subjects are expected to participate in this project.
7. The risks or discomforts which are possible are as follows: There are no additional risks or discomforts associated with this study beyond those normally present during the course of anesthesia care .
8. I understand that the research may not help me personally but that the results may help the investigator learn about the effects of room air oxygen on oxygen levels in the blood during transport from the operating room to the recovery room.

Subject/Patient Initials

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9. I understand that this project is not designed to treat any medical condition that I may have, therefore there is no alternative procedure course of treatment that would be advantageous to me. If you elect not to enroll in the study, it does not necessarily mean that you will be given extra oxygen during transport.

10. In all publications and presentations resulting from this research project, my anonymity will be protected to the maximum extent possible; although, I realize that authorized Navy Medical Department personnel may have access to my research file in order to verify that my rights have been safeguarded.

11. If I suffer any physical injury as a result of my participation in this study, immediate medical treatment is available at the National Naval Medical Center, Bethesda, Maryland. I understand that although no compensation is available, any injury as a result of my participation will be evaluated and treated in keeping with the benefits or care to which I am entitled under applicable regulations.

12. If I have any questions regarding this research project, I may contact CPT David W. Cherni at (301) 295-6565 or LCDR Biegner (301) 295-4455 Ext. 158. If I have any questions regarding my rights as an individual while participating in a research project at the National Naval Medical Center, Bethesda, I can contact one of the Research Administrators, Clinical Investigation Department, at (301) 295-2275. They will answer my questions or refer me to a member of the Institutional Review Board (IRB) for further information. If I believe I have been injured as a result of this project I may call the legal office (301) 295-2215.

13. I understand that my participation in this project is voluntary and that my refusal to participate will involve no penalty or loss of benefits to which I am entitled under applicable regulations. If I choose to participate, I am free to ask questions or to withdraw from the project at any time. If I should decide to withdraw from the research project, I will notify CPT David W. Cherni at (301) 295-6565, or LCDR Biegner at (301) 295-4455 Ext. 158 to ensure an orderly termination process. My withdrawal will involve no loss of benefits to which I am entitled.

Patient Initials

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14. The investigator may terminate my participation in this project for the following reasons:

1) Inability to meet the inclusion criteria

15. I have been informed that there will not be additional costs to me beyond those normally associated with my care at NNMCMC if I choose to participate in this project.

16. I understand that I may withdraw from this study at any time without prejudice to my future care. I understand that if I withdraw from this project I will not lose any benefits to which I am otherwise entitled.

17. Any new significant finding developed during the course of the research which may effect my willingness to participate further will be explained to me.

18. I understand that if, in the future, I am no longer eligible for health care as a DoD beneficiary, my participation in this research project does not guarantee me future medical care. I understand that if I am no longer a DoD beneficiary, I may not be able to obtain medical treatment from a DoD health care facility for any injuries or side effects that result from my participation in this research project. I may be responsible for seeking treatment elsewhere.

I certify that I have received a copy of this consent form.

Date Signed

Patient/Subject Signature

Typed Name-Status-Sponsor's  
SSN

Witness' Signature & Date

Investigator Signature &  
Date

Witness'typed Name-Rank-  
SSN

Investigator typed Name-  
Rank-SSN

## PRIVACY ACT STATEMENT

1. Authority. 5 USC 301
2. Purpose. Medical research information will be collected to enhance basic medical knowledge, or to develop tests, procedures, and equipment to improve the diagnosis, treatment, or prevention of illness, injury or performance impairment.
3. Use. Medical research information will be used for statistical analysis and reports by the Departments of the Navy and Defense, and other U.S. Government agencies, provided this use is compatible with the purpose for which the information was collected. Use of the information may be granted to non-Government agencies or individuals by the Chief, Bureau of Medicine and Surgery in accordance with the provisions of the Freedom of Information Act.
4. Disclosure. I understand that all information contained in this Consent Statement or derived from the experiment described herein will be retained permanently at National Naval Medical Center, Bethesda, Maryland and salient portions thereof may be entered into my health record. I voluntarily agree to its disclosure to agencies or individuals identified in the preceding paragraph and I have been informed that failure to agree to such disclosure may negate the purposes for which the experiment was conducted.

Subject/Guardian Signature

Signature of Witness

Typed Name, Grade or Rank

Date of birth

## Appendix B

## Data Collection Sheet

**Subject Number:**\_\_\_\_\_ **ASA status:** I II **Date:**\_\_\_\_\_

**Age:**\_\_\_\_\_ **Male / Female** **Weight:**\_\_\_\_\_

**Preop baseline SpO<sub>2</sub>:**\_\_\_\_\_

**Type Of Anesthesia:**

Preop Sedation: \_\_\_Midazolam Other:\_\_\_\_\_

IV agents: \_\_\_Pentothol \_\_\_Propofol \_\_\_Ketamine \_\_\_Etomidate  
Other:\_\_\_\_\_

Inhalational: \_\_\_Isoflurane \_\_\_Halothane \_\_\_Desflurane \_\_\_  
Sevoflurane

Narcotics: \_\_\_Fentanyl \_\_\_Sufentanil \_\_\_Alfentanil \_\_\_  
Remifentanil \_\_\_Morphine

**NMR:** YES NO

**Tetany:** YES NO

**SpO<sub>2</sub> #1**\_\_\_\_\_

**SpO<sub>2</sub> #2**\_\_\_\_\_

**Anesthesia start time:** \_\_\_\_\_ **Anesthesia stop Time:**\_\_\_\_\_